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Integration between *Building Information Modeling* (BIM) and *Lean Construction:* Innovation, Efficiency, and Sustainability in the Construction Sector

Integration between Building Information Modeling (BIM) and Lean Construction: Innovation, Efficiency, and Sustainability in the Construction Sector

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Abstract:

Aiming to analyze how the integration between *Building Information Modeling (BIM)* and *Lean Construction* philosophy can strengthen innovation, productive efficiency, and sustainability in the construction sector, this article conducts a theoretical and documentary review of the synergies and limitations of this methodological convergence. The analysis shows that BIM, by structuring integrated and collaborative digital models, and *Lean Construction,* by guiding the rationalization of workflows and the elimination of waste, constitute complementary approaches capable of improving the planning, control, and execution of construction projects. The results indicate that the articulated adoption of these practices contributes to greater predictability of deadlines and costs, reduction of rework, improved transparency, and strengthening of data-driven management.

Keywords: BIM; Lean Construction; Innovation; Productive Efficiency; Sustainability; Civil Construction.

Abstract

With the objective of analyzing how the integration between Building Information Modeling (BIM) and the Lean Construction philosophy can strengthen innovation, productive efficiency, and sustainability in the construction sector, this article conducts a theoretical and documentary review of the synergies and limitations of this methodological convergence. The analysis demonstrates that BIM, by structuring integrated and collaborative digital models, and Lean Construction, by guiding the rationalization of workflows and the elimination of waste, constitute complementary approaches capable of enhancing the planning, control, and execution of construction projects. The results indicate that the articulated adoption of these practices contributes to greater predictability of schedules and costs, reduction of rework, improvement of transparency, and strengthening of data-driven management.

Keywords: BIM; Lean Construction; Innovation; Productive Efficiency; Sustainability; Construction Industry.

1. Introduction

The construction industry has historically faced structural challenges related to low... productivity, process fragmentation, and the high costs resulting from rework, Waste and inconsistencies between design and execution. Pioneering studies indicate that construction It operates under a production model characterized by variability, unpredictable flows, and significant... Economic inefficiency, which compromises both the quality and competitiveness of the projects. (Koskela, 1992; Womack, Jones and Roos, 1990). Financial losses are added to these factors.

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resulting from a lack of methodological integration, communication problems between teams and limitations in the ability to predict costs and risks throughout the project lifecycle.

In this scenario, BIM presents itself as a digital approach capable of reconfiguring the Technical and economic management of construction projects. By integrating geometric information, By integrating material, budgetary, and temporal aspects into dynamic digital models, BIM facilitates analysis. cost comparisons, simulations of construction alternatives, and greater accuracy in estimation. budgetary (Eastman et al., 2011; Succar, 2009). This ability to generate financial projections More consistent methods increase the predictability of projects, contributing to a reduction in the total cost of... A project throughout its life cycle, including maintenance and operation (Azhar, 2011).

In parallel, the *Lean Construction* philosophy proposes the systematic elimination of waste reduction, increased continuous workflow, and planning reliability, with Direct impacts on reducing production costs. Based on principles derived from the Toyota Production System. In the field of Production, classic authors emphasize that the rationalization of processes, standardization, and Collaborative control is a key element in minimizing financial losses and optimizing... resources (Ohno, 1988; Womack and Jones, 2003; Ballard and Howell, 2003). In civil construction, these These practices translate into less operational variability, reduced interruptions, and decreased costs. Rework is a factor that generates cost savings and increases the overall efficiency of the project.

In recent years, the convergence between BIM and Lean Construction has been the subject of numerous studies. studies, supported by the complementarity between collaborative digital modeling and management Lean, focused on economic performance. Research indicates that integrating the two approaches... It contributes to optimizing direct and indirect costs, improving risk management, and expanding... reliability of financial decisions in ventures (Sacks et al., 2010; Dave, Koskela and Kowaltowski, 2013). The synergy between 4D and 5D BIM models and Lean planning does not result in... Not only in greater accuracy of deadlines and budgets, but also in more solid governance. based on data.

By combining technological innovation, productive efficiency, and economic sustainability, the BIM-Lean integration represents an opportunity to improve financial efficiency in the sector. of construction. In addition to reducing costs and mitigating risks, this convergence can strengthen the competitiveness of organizations, supporting indicator-driven decisions, and contributing to a More responsible use of productive resources.

Based on this overview, the research identifies the following question as the central problem: *in To what extent can the integration between Building Information Modeling (BIM) and Lean Construction to optimize cost management in civil construction, reducing waste and increasing efficiency. How can we improve budgetary predictability and increase the economic and financial efficiency of projects?*

Thus, the overall objective is to evaluate, from a cost accounting perspective...

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applied to construction, such as the convergence between digital modeling technologies and principles of Lean production contributes to the assertive control of direct and indirect costs, and the mitigation of... rework, improved performance indicators (CPI, SPI, TCO, ROI), as well as strengthening of the financial sustainability of the projects.

In this context, when considering the state of the art regarding the integration between BIM and Lean Construction, This article focuses on analyzing the economic and financial implications arising from this. methodological convergence.

This perspective engages with the author's previous studies, which analyze how technologies... Digital technologies, especially the Internet of Things (IoT), are reshaping production practices and expanding the... Efficiency and sustainability in agricultural and organizational systems (Stroparo, 2024a; 2024b). These investigations demonstrate that digitization can reduce structural inefficiencies and strengthen Decision-making processes and optimizing the use of resources are fundamental principles that align with the logic of integration. BIM-Lean is discussed in this article.

2. Theoretical Framework / Results

The *National Committee for Building Information Modeling Standards* (NBIMS) in the States The United States (USA) conceptualizes *Building Information Modeling (BIM)* as a digital representation. of the physical and functional characteristics of a facility. As a shared resource of With this knowledge, BIM forms a reliable basis for decisions throughout the building lifecycle. from conception to demolition (NBIMS-US, National Institute of Building Sciences, 2021).

BIM, or Building Information Modeling, is a modeling technology that... It uses three-dimensional software to operate in real time, providing continuous and up-to-date information. High quality information about a construction project. It covers geometric, geographical, and data. properties of the building components, as well as information on scope, schedule and costs. (Díaz et al., 2014, p. 48).

More specifically, BIM allows the creation of digital models that accumulate detailed information about the design, construction and operation of the buildings Oliveira et al., 2023, p. 260. These models function as a centralized database, integrating various Information such as engineering data, schedules, and costs, representing progress. significant in relation to traditional methods (Silva & Santos, 2025, p. 6).

Among the main benefits of BIM, we can mention: Enhanced collaboration: It facilitates the exchange of ideas and reduces errors and omissions, thus decreasing the waste of resources and time. and labor (Gnecco et al., 2021, p. 143); Project optimization: Allows the elimination of potential design flaws in the design phase, resulting in reduced costs and time (Gonzalez et al., 2024, p. 2); Visualization and analysis: Three-dimensional visualization and advanced analysis enable the

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Identifying and resolving design problems before execution, optimizing the project and Improving sustainability (Gutiérrez & Espinosa, 2024); Sustainability: Contributes to Sustainable construction by simulating energy performance and allowing the selection of more sustainable materials. suitable, evaluating and optimizing the ecological impact of projects (Gutiérrez & Espinosa, 2024; Mattana & Librelotto, 2017); Unification and centralization: Unifies the construction model, centralizing and integrating information into a three-dimensional model updated in real time, providing a comprehensive view of the project and facilitating collaboration (Mattana & Librelotto, 2017, p. 135; Silva & Santos, 2025, p. 6).

In short, BIM is a tool used for the digitalization of the construction industry. Promoting efficiency, collaboration, and sustainability throughout the entire project lifecycle. While Lean Construction is a management philosophy originating from... Lean production principles, with the main objective of optimizing workflows and eliminating waste. waste in the construction industry (Oliveira et al., 2023).

On the other hand, the *Lean Construction* philosophy is widely recognized as a Adapting the principles of lean production to the construction sector, based on the pursuit of... continuous focus on generating value for the customer and systematically eliminating waste throughout The entire production cycle. According to the *Lean Construction Institute* (LCI), this is "a way of To design and build using lean management concepts to reduce material waste. time and effort, with the goal of generating the maximum possible value" *(Lean Construction Institute,* 2024).

Along the same lines, there is the *International Group for Lean Construction (IGLC) ,* which reinforces this point. This concept, by stating that *Lean Construction* stems from an orientation towards continuous flow, Production reliability and continuous improvement, characteristics initially structured by Koskela in his seminal report *Application of the New Production Philosophy to Construction* (Koskela, 1992).

In the Brazilian context, the *Lean Construction Institute Brazil* (LCI-BR) defines the approach as a system geared towards process stability and value delivery through reduction of variability and collaborative integration between teams (Lean Construction Institute Brazil, 2023). Thus, a conceptual alignment can be observed between the main international institutes, which They converge on the understanding that Lean Construction constitutes a management philosophy based on... in the reliability of the production flow, in the elimination of waste and in the optimization of processes. constructive.

Based on these theoretical foundations, the International Institute for Lean Construction (IGLC) This spurred the scientific consolidation of the field. Subsequent research delved deeper into topics such as collaborative planning, production control, operational variability and standardization of

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processes. The development of the *Last Planner System* was particularly relevant, as it demonstrated Empirically, how does collaborative task management reduce uncertainty and improve efficiency? economic aspects of construction projects (Ballard and Howell, 2003). Recent studies indicate that the application of Lean principles in construction result in less material waste and reduced rework. and greater financial predictability.

The core elements of Lean philosophy include: Continuous Flow: Focus on creating a Uninterrupted workflow for all project activities, from conception to delivery. (Oliveira et al., 2023); Waste Elimination: Identification and removal of any activity that does not add value to the final product, such as rework, excess inventory, waiting times, and movement. unnecessary, among others (Aziz et al., 2024; Oliveira et al., 2023); Value Maximization: Focus on delivering maximum value to the customer with minimum resources (Aziz et al., 2024).

In essence, *Lean Construction* seeks to improve the productivity and sustainability of... construction projects through process optimization and digitization Oliveira et al., 2023, p. 260. When integrated with other methodologies such as BIM, Lean Construction enhances management. of projects by aligning their principles with the technical capabilities of BIM, resulting in greater efficiency and collaboration (Aziz et al., 2024; Oliveira et al., 2023).

However, the first theoretical formulations that underpin BIM date back to The 1970s and 1980s, when researchers began exploring digital systems capable of to represent buildings in an integrated way, overcoming the limitations of two-dimensional drawings. traditional (Eastman, 1975). These initial efforts were strengthened by advances in computing. Graphic design and the development of object-oriented models, which allowed for the association between geometry and constructive attributes.

During the 1990s, the concept of information modeling applied to construction It has been consolidated through research on interoperability and digital collaborative environments. The work of Eastman and colleagues became a benchmark by systematizing the technological fundamentals and operational aspects of BIM, highlighting its ability to integrate data throughout the lifecycle of undertaking (Eastman et al., 2011). Simultaneously, studies sought to structure frameworks conceptual frameworks for understanding the different levels of maturity and uses of BIM in industry. highlighting the need for alignment between processes, standards, and collaborative platforms. (Succar, 2009). This approach broadened the understanding of BIM as a methodology. comprehensive, and not just software or a graphical tool.

The evolution of BIM has also been strongly associated with concerns related to Cost optimization, construction performance, and sustainability. Research has shown that... Integrated digital modeling allows for improved budget estimates and reduced inconsistencies.

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between design and execution and anticipate financial impacts of different construction solutions (Azhar, (2011). Thus, BIM has established itself as a strategic approach that, in addition to improving the Interdisciplinary communication provides decision-making support based on accurate and up-to-date data.

2.1 Conceptual convergence between BIM and Lean Construction: bases for integration

The convergence between BIM and Lean Construction strengthened starting in the 2000s, when Researchers began exploring synergies between digital modeling and interdisciplinary collaboration. and streamlining production processes. Studies show that BIM provides support. Informational and technological support for Lean practices, enabling accurate visualizations and early detection. of interferences, schedule simulations and financial estimates (Sacks et al., 2010). On the other hand On the one hand, Lean philosophy guides the use of BIM for purposes of economic optimization and cost reduction. Waste reduction and increased value of continuous workflow.

Integrative research indicates that the BIM-Lean combination contributes to the creation of more efficient management systems, with significant impacts on productivity, quality and... financial performance of ventures. The literature highlights that this convergence This methodological approach offers advantages such as greater reliability in planning and reduced variations. improving cost control and strengthening data-driven decisions (Dave, Koskela) (and Kowaltowski, 2013). Thus, the integration between BIM and Lean Construction is recognized as a A fundamental contemporary strategy for building innovative production models. sustainable and more economically robust.

2.2 Economic-Financial Effects and Sustainability of BIM-Lean Integration

The integration between BIM and Lean Construction has been recognized in the literature as a a strategy capable of generating profound transformations in economic, environmental and performance operational aspects of construction projects. These impacts result from the convergence between the the informational and predictive capacity of BIM and the procedural rationality of Lean philosophy, which emphasizes the elimination of waste, continuous improvement, and value creation (Koskela, 1992; Ohno, 1988; Womack and Jones, 2003).

Several studies indicate that the integrated application of BIM and Lean contributes in a significant way. significant for reducing direct costs — such as materials, labor, and technical hours — and Indirect costs, related to delays, rework, interference, and planning failures. BIM's ability to perform early conflict detection and 4D and 5D simulations allows for prediction. financial scenarios and avoid incompatibilities that, when not identified, result in significant budget increases (Eastman et al., 2011; Azhar, 2011). Simultaneously, the Lean principles reduce variability and interruptions in the production flow, which decreases losses. financial costs associated with idle time, unnecessary inventory, and rework (Ballard and Howell, 2003).

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Recent research proposes integrative frameworks that articulate BIM and Lean. Construction and sustainability as interdependent dimensions. Mellado and Lou (2020) argue The alignment between these approaches allows for simultaneous gains in productive performance. Energy efficiency and reduction of environmental impacts. Similarly, Yang et al. (2025) They argue that methodological integration plays a strategic role in the transition to new environments. sustainable buildings, especially when incorporated with objective indicators of value, flow and environmental impact.

Empirical studies report cost reductions ranging from 10% to 25% when practices are implemented. Collaborative digital tools and lean processes are used in an articulated way, especially in complex projects. These economies derive from increased productivity, improved in the reliability of planning and the ability to monitor costs in real time.

BIM-Lean integration strengthens the financial predictability of projects by improving the Quality of information, reducing uncertainties, and enabling the early evaluation of alternatives. constructive. Digital modeling allows for more accurate estimates of costs, material consumption, Impacts of the maintenance schedule and projections, enabling total cycle cost analyses. Lifecycle Competency (LCC). By complementing these capabilities with Lean principles, the planning process It becomes more participatory, disciplined, and reliable, reducing variations that commonly occur. They compromise the budget (Sacks et al., 2010).

This predictability is essential not only for financial management, but also for... Organizational competitiveness. Research shows that integrated systems capable of aligning Planning, costing, and production enable decisions based on robust data, increasing efficiency. effectiveness of material choices, execution methods and activity sequencing (Dave, Koskela and Kowaltowski, 2013).

Adopting BIM-Lean practices reduces risks related to delays, contract addendums, Execution failures and budget overheating, strengthening the economic sustainability of Lean's emphasis on flow stability and task reliability allows for... to minimize the likelihood of unforeseen interruptions, while BIM provides a foundation. Integrated information system for continuous monitoring of financial and operational risks.

This alignment contributes to economic sustainability in the medium and long term, a Since more predictable and efficient projects require lower maintenance costs. Corrective maintenance results in less performance loss and extends the lifespan of building systems.

2.3 Environmental sustainability: waste reduction and resource optimization

The environmental dimension is also enhanced by BIM-Lean integration. The literature points out The construction industry is one of the sectors that generates the most solid waste and consumes large volumes of it. of natural resources. The rationalization of Lean processes contributes to the reduction of these wastes.

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by eliminating waste, avoiding unnecessary activities and optimizing workflows (Womack and Jones, 2003). BIM, in turn, enables energy performance simulations and precise calculations. of material quantities and strategic logistics planning, avoiding surpluses and minimizing environmental impacts (Succar, 2009).

This combined approach supports more sustainable building practices, aligned with Trends in ecological modernization and environmental responsibility in the sector, by reducing the volume of resources employed, improve energy efficiency and reduce emissions associated with production. and to the transportation of materials.

Although the main focus of this study is on the economic and financial dimension, integration BIM-Lean has social and governance implications, promoting greater transparency. Traceability and collaboration between teams. Integrated, data-driven management increases... It fosters trust among the parties involved and reduces contractual conflicts, strengthening cooperation networks and promoting more efficient and sustainable organizational environments.

The discussion on sustainability and socio-technical innovation also finds support in The author's scientific production explores the interrelationships between socio-technical imaginaries and innovation. openness and socio-environmental autonomy in rural territories (Stroparo, 2025a; Stroparo; Floriani, 2025). These studies highlight that technological transformation in production chains depends on certain conditions. sociopolitical, cultural, and organizational factors that shape the adoption of sustainable practices — aspect convergent with the BIM-Lean-Sustainability integration presented in this study.

3. Materials and Methods

The research adopts the design of a *scoping review ,* which is an approach... a methodology recognized for its ability to map concepts, identify trends, and synthesize. The state of the art in complex and multifaceted fields.

The methodological foundation follows the guidelines proposed by Arksey and O'Malley, who They established *scoping review* as a suitable tool for exploring broad and narrow topics. consolidated, offering a panoramic view of the available evidence (Arksey; O'Malley, 2005).

Furthermore, the study incorporates methodological improvements suggested by Levac, Colquhoun and O'Brien, who advocate for greater clarity in formulating the purpose of the review, rigor in selection of evidence and reflexivity in the synthesis process (Levac; Colquhoun; O'Brien, 2010). Contemporary guidelines proposed in the *JBI Manual for Evidence* were also considered. *Synthesis,* which reinforces the use of *scoping review* to structure conceptual mappings in areas. emerging (Peters et al., 2020).

Thus, the investigative process was based on the identification, selection, and analysis of Studies on BIM, Lean Construction and their interfaces, with emphasis on economic impacts.

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financial and in contributions to sustainability.

The search was conducted in internationally relevant databases and used descriptors. associated with information modeling, lean production, BIM-Lean integration, cost efficiency. and sustainability in construction.

The selection of literature incorporated foundational works, such as the studies of Koskela, which They proposed the formulation of the lean production philosophy applied to construction (Koskela, 1992), as well such as the works of Ohno, which consolidated the principles of the Toyota Production System (Ohno, 1988) and the analyses of Womack and Jones, who investigated the logic of lean production in the context industrial (Womack; Jones, 2003).

In the field of information modeling, classic references by Eastman were included. and collaborators, who systematized the fundamentals of BIM and its applications throughout the lifecycle of lifecycle of the enterprise (Eastman et al., 2011), and contributions such as those of Succar, which structured Conceptual frameworks of maturity and uses of digital modeling (Succar, 2009). To explore the Given the convergence between BIM and Lean, studies have been conducted that analyze the interaction between these two technologies. approaches, especially the research of Sacks and of Dave, Koskela and Kowaltowski, which They empirically demonstrate the productivity gains, cost reductions, and benefits. organizational changes resulting from integration (Sacks et al., 2010; Dave; Koskela; Kowaltowski, 2013). Since this is a purely theoretical study, the research does not involve the collection of empirical data. It does not require review by an ethics committee.

4. Results and Discussion

The literature reviewed demonstrates that the integration between BIM and *Lean Construction* constitutes a methodological convergence capable of reconfiguring traditional practices in the construction sector, especially with regard to economic efficiency, waste reduction and strengthening of sustainability. This convergence stems from the structured relationship between digital technologies, which They provide informational support and management principles geared towards eliminating losses and improving cash flow. Continuous production. Research consistently indicates that BIM provides precision, Predictability and reliability of project information, while Lean contributes to discipline. processes, reduce variability and stabilize the productive environment (Sacks et al., 2010; Dave; Koskela; Kowaltowski, 2013).

From an economic and financial point of view, there is evidence that the integrated adoption of BIM and Lean promotes significant reductions in the direct and indirect costs of construction projects. Parametric models and Multidimensional simulations allow for the anticipation of interferences and inconsistencies, preventing problems. Rework and minimizing budget overruns. At the same time, streamlining workflows. The work methodology proposed by Lean reduces idle time, decreases inventory, and avoids interruptions.

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unproductive factors, which represent significant financial losses when left unchecked. (Ballard; Howell, 2003; Eastman et al., 2011).

Empirical studies demonstrate cost reductions exceeding 20% in projects. which adopted integrated practices, indicating that digitalization aligned with lean production consolidates More reliable processes that are less susceptible to deviations.

In line with the author's previous research on cost management, technologies emerging and innovations applied to production systems (Stroparo; Araújo; Bortolotti; Lacerda Junior, (2024), the reviewed literature indicates that the integration between BIM and Lean can promote gains. significant in financial efficiency, budget predictability, and economic sustainability. Studies conducted by the author also demonstrate that digital processes tend to reduce informational asymmetries and increased control over losses and waste, which reinforces the potential The transformative aspect of the methodological integration discussed in this article.

In addition to these aspects, recent research has emphasized the importance of indicators of Performance in enabling and monitoring BIM-Lean integration.

Indicators such as ROI *(Return on Investment),* TCO *(Total Cost of Ownership),* CPI *(Cost Performance Index),* SPI *(Schedule Performance Index)* and production flow variability indices. They have been used to assess the efficiency and financial sustainability of projects.

International studies suggest that the systematic use of these indicators makes it possible not only to measure economic gains, but also to predict risks and estimate impacts on the cycle of building life and support evidence-based strategic decisions (Formoso et al., 2011; Frandson; Bergstrom; Tommelein, 2013).

The literature reinforces that integrating these metrics with BIM digital environments strengthens Project governance, as it allows for tracking costs, productivity, and performance in real time. expanding organizational responsiveness.

Another relevant point concerns environmental sustainability, which is frequently highlighted. as one of the main benefits of BIM-Lean convergence. The Lean philosophy, by directing Efforts toward the systematic elimination of waste directly contribute to the reduction of... The amount of solid waste generated, in order to reduce material consumption and optimize... Use of natural resources throughout the construction.

BIM, in turn, allows for comparative analyses of materials, energy simulations, and... projections of environmental performance, favoring the adoption of more environmentally friendly construction solutions. Sustainable practices. Studies show that integrating these approaches contributes to aligned practices. By *designing for sustainability,* we can make data-driven decisions and reduce our carbon footprint. and increasing the energy efficiency of developments (Azhar; Carlton; Olsen; Ahmad, 2011; Wong; Zhou, 2015)

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Similar research reinforces this perspective. Studies conducted by Nahangi and Collaborators demonstrated that BIM models integrated with Lean practices result in a reduction of Waste reduction and increased energy efficiency in residential and commercial projects. Further research, Studies by Marzouk and Azab indicate that the use of environmental simulations in BIM combined with Lean strategies contribute to reducing environmental impacts throughout the stages of construction and operation. These findings suggest that methodological integration not only optimizes costs, but it also enables processes that are more in line with carbon neutrality and the economy. circular and the Sustainable Development Goals (SDGs).

The literature also reveals a significant expansion of studies that use BIM as A tool to improve circularity in the construction sector. Karanafti et al. (2024) demonstrate What digital models can support the management of construction and demolition waste, contributing to... Circular economy practices. McNeil-Ayuk and Jrade (2024) reinforce this trend by proposing a Integrated BIM + Circular Economy model to optimize deconstruction processes, highlighting environmental and economic gains.

Furthermore, the literature highlights that the benefits of BIM-Lean integration go beyond Technical and financial dimensions, involving social and governance aspects. Digital models. Shared resources promote transparency, reduce information asymmetry, and strengthen... Collaboration between multidisciplinary teams, while Lean principles enhance reliability. tasks and foster continuous improvement cycles. These elements, combined, promote more stable, collaborative, and results-oriented work environments, which has an impact positively impacts project management and organizational competitiveness (Womack; Jones, 2003; Sacks et al., 2010).

Despite the progress, significant challenges remain for integrated implementation. of these practices. Cultural resistance, the initial costs of adopting digital technologies, the lack The lack of technical training and the structural fragmentation of the industry continue to be cited as Barriers to productive transformation. The literature indicates that the isolated adoption of these methodologies tends to yield limited results, reinforcing that true innovation emerges when BIM and Lean principles are incorporated in an articulated and strategic way, involving technological changes and simultaneous organizational changes (Koskela, 1992; Dave; Koskela; Kowaltowski, 2013).

In summary, the discussion highlights that BIM-Lean integration has significant potential. to improve economic efficiency, reduce environmental impacts, and strengthen processes of Governance and promoting innovation in the construction sector. National and international research. They demonstrate that this methodological convergence is part of a broader movement of Modernization of the industry, guided by sustainable practices and data-driven decisions. The consolidation of this process, however, depends on overcoming structural barriers and...

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Implementation of continuous strategies for capacity building, standardization, and technological integration.

Recent studies reinforce that advances in the integration between BIM and sustainability have significantly expanded the analytical capabilities of digital models, enabling simulations. Energy efficiency assessments, life cycle evaluations, and automated comparisons of construction alternatives. A comprehensive review conducted by Akbari et al. (2024) identifies that, although BIM is already widely used for environmental assessments, important gaps still persist related to it. to interoperability, standardization of indicators, and integration with Lean methodologies. The The authors emphasize that the future of sustainable construction will depend on the convergence between BIM and Lean. and circular economy tools, forming digital ecosystems capable of guiding decisions. From conception to operation.

In the Brazilian context, studies indicate that the adoption of BIM has generated positive impacts. both in the sustainability and efficiency of public works. Gnecco, Mattana and Fossati (2021) They show significant reductions in the volume of waste on construction sites when applying BIM processes. Santos et al. (2021) highlight that, despite the progress, the implementation of BIM in Brazil is still It faces institutional challenges, especially in the public sector.

To deepen the understanding of the theoretical and empirical contributions that underpin the In the field of BIM-Lean-Sustainability integration, a comparative table was developed with the The main studies identified in the scoping review are presented in Table 1. It synthesizes methods, objectives, findings, and gaps, allowing visualization of analytical convergences and the challenges that still persist in literature.

Table 1 – Summary of the main studies on BIM, Lean Construction and Sustainability

Authors / Year	**Method**	**Objective**	**Main Findings**	**Contribution Theoretical**	**Gaps Identified**
Akbari et al. (2024)	Systematic review	BIM Mapping + Sustainability	Identifies gaps, trends, and interoperability challenges.	It updates the state of the art by integrating sustainability.	Integration with Lean still limited
Andújar-Montoya et al. (2019)	Literature review	Analyze interactions BIM-Lean	It highlights structural synergies between BIM and Lean	First consolidated overview of integration	Few robust empirical studies
Aziz et al. (2024)	Applied study	Evaluating BIM as a Lean tool in the design phase	BIM reduces waste and improves coordination.	It demonstrates direct BIM-Lean integration in design.	It does not include economic metrics.
Daoud et al. (2025)	PLS-SEM	Evaluate benefits of BIM in sustainable construction	BIM improves operational and design sustainability.	Strong quantitative contribution	It does not address Lean
Díaz, Sánchez & Guerra (2014)	Theoretical-applied study	Structuring Lean fundamentals in construction.	Define Lean practices applicable to the Latin American context.	Advances Lean fundamentals for construction.	Does not include BIM
Gnecco et al. (2021)	Study of case	Reducing waste in public works projects using BIM.	Significant reduction in RCC	Show application BIM in the Brazilian context	Limited scope of public the works
Gonzalez et al. (2024)	Experimental study	Integrate BIM and Kanban	Digital Kanban improves production flow.	Disruptive methodology of	Little validation

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	al			management	empirical
Gutiérrez & Espinosa (2024)	Bibliometric analysis here	Mapping structure the theme of BIM + sustainability	Identifies emerging thematic cores	Contributes to future research.	It doesn't focus on Lean.
Karanafti et al. (2024)	Review + Applications	BIM in waste management: circularity and	BIM reduces waste. CD	in Advancement of applied circular economy	Without explicit Lean integration
Marzouk & Azab (2016)	Modeling m environmental	BIM + Lean for environmental efficiency	It reduces environmental impacts and improves efficiency	It integrates sustainability and lean production.	Limited sample
Mattana & Librelotto (2017)	National study	Assessing BIM in economic sustainability	BIM reduces lifecycle costs.	Brazilian contribution to the topic	No arguing. Lean
McNeil-Ayuk & Jrade (2024)	Integrated model	BIM + Economy Circular	Optimizes deconstruction, reduces impacts.	Contributes to the to the debate on circularity.	Lack of integration BIM-Lean
Mehran, Poirier & Forgues (2022)	Theoretical study	BIM + Lean for value creation	It integrates information and flow.	Discussion on value progresses.	Limited practical application.
Mellado & Lou (2020)	Framework k	BIM + Lean + Sustainability	They propose full integration of approaches.	Modern conceptual framework	Requires empirical validation.
Mota et al. (2019)	Applied study	Evaluating BIM in production systems	Reducing variability and failures	It demonstrates real challenges.	There is a lack of explicit correlation with indicators.
Oliveira, Silva & Amaral (2023)	Conceptual study	BIM-Lean Relationships in Brazil	Conceptual interactions mapping	Relevant for national context	Practical applications are lacking.
Paula et al. (2017)	Mapeamen systematic	BIM for compatibility	Reducing conflicts and rework.	Strengthens adoption BIM in Brazil	It does not address Lean
Santos et al. (2021)	Comparative study the	Compare BIM between Brazil and UK	Brazil is making progress, but faces institutional barriers.	Broad international perspective	It does not analyze. Lean
Schamne et al. (2022)	BIM Review for RCC		Show BIM automating waste management	Contributes to the to the Brazilian debate.	Without Lean
Silva & Santos (2025)	Revision	BIM Trends	Define megatrends BIM in Brazil	Relevant for digital innovation	It does not integrate sustainability. of
Yang et al. (2025)	Systematic review	BIM–Lean–Sustainability	Identifies paths integrated futures	One of the most modern revisions	This suggests further research into indicators.

Source: Prepared by the author, based on Akbari et al. (2024); Andújar-Montoya et al. (2019); Aziz et al. (2024); Daoud et al. (2025); Díaz, Sánchez and Guerra (2014); Gnecco, Mattana and Fossati (2021); Gonzalez et al. (2024); Gutiérrez and Espinosa (2024); Karanafti et al. (2024); Marzouk and Azab (2016); Mattana and Librelotto (2017); McNeil-Ayuk and Jrade (2024); Mehran, Poirier and Forgues (2022); Mellado and Lou (2020); Mota et al. (2019); Oliveira, Silva and Amaral (2023); Paula et al. (2017); Santos et al. (2021); Schamne, Nagalli and Soeiro (2022); Silva and Santos (2025); Yang et al. (2025).

Table 1 summarizes the main studies identified in the scoping review regarding Integration between BIM, Lean Construction and sustainability, allowing visualization in a way A systematic analysis of the conceptual and methodological evolution of this field of research. Comparative analysis reveals that the literature exhibits strong heterogeneity regarding methods. employed — ranging from systematic reviews, case studies, environmental modeling, bibliometric analyses and experimental applications demonstrate the multidimensionality of the topic.

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and its increasing theoretical complexity.

It is observed that a significant portion of the studies focuses on identifying synergies. between BIM and Lean, highlighting gains associated with waste reduction and improved... Project coordination, rework mitigation, and stability of production flows. However, Despite these advances, the amount of research that integrates simultaneously remains limited. economic indicators, sustainability metrics, and life cycle analyses, which reflects gaps still relatively unexplored in the field. Similarly, studies that connect BIM, Lean, and economics. circular theories—although emerging—still lack greater empirical robustness, especially in Latin American context.

The chart also shows that, while some projects are progressing in their development... While some focus on integrative frameworks, others concentrate on the application of digital tools for... specific problems, such as geometric compatibility, reduction of construction waste and Identification of interferences. In terms of theoretical contributions, a convergence is observed. in recognition that the integration between BIM and Lean has the potential to reshape practices. productive and promote significant efficiency gains, both operational and economic. financial.

On the other hand, recurring gaps include the absence of large-scale empirical validation. scale, lack of standardization of indicators, scarcity of studies exploring the impact The economic data is quantified, and there is limited research into institutional and cultural barriers. in the integrated adoption of these approaches. In this sense, the set of studies summarized in the table This highlights the need for research agendas that systematically explore the interfaces. between technology, management, sustainability and costs, consolidating more robust foundations for the Digital transformation of the construction industry.

The following Indicators Chart presents a set of widely used metrics. in the literature to evaluate the economic, operational, and sustainable performance of ventures that adopt integrated BIM and *Lean Construction practices.* These indicators allow for quantification, In an objective way, the impacts of digitalization and lean production on costs, deadlines, and efficiency. energy, waste generation and stability of production flows, constituting as essential tools for evidence-based decision-making. The systematization of these The parameters show that the combined use of BIM and Lean enhances the ability to... Real-time monitoring improves performance predictability and contributes to better management. more rational use of resources throughout the building's life cycle. Thus, the following table does not It not only organizes the main recurring indicators in the literature, but also demonstrates how each one... One of them can be operationalized within distinct digital and methodological environments. reinforcing its relevance for economic and financial analyses and for sustainability in the sector of

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construction.

Table 2 – Financial and Operational Indicators for Evaluating Economic Performance in BIM-Lean Integration

Indicator	**Description**	**BIM Application**	**Lean Application**	**Relevance to Sustainability**
ROI – Return on Investment	return of Financial investment measure	BIM generates models to predict costs throughout the lifecycle.	Lean reduces waste, increasing operating profit.	Assess the feasibility of sustainable solutions.
TCO – Total Cost of Ownership	Total life cycle cost	BIM allows simulations maintenance and operation	Lean avoids rework, which increases the product lifecycle.	It encourages more durable materials.
CPI – Cost Performance Index	actual cost performance planned ×	BIM updates costs in real time.	Lean reduces deviations.	Avoid overconsumption of materials.
SPI – Schedule Performance Index	Schedule performance	BIM Updates 4D schedules.	Lean increases reliability planning	Reduces wasted time/ energy
TVF – Rate of Variability of Flow	Measures the stability of the production flow.	BIM simulate constructive sequences	Lean stabilizes production rate (Takt Time)	Stable airflow reduces emissions.
RNC – Rework Non-compliant	Measures errors and incompatibilities.	BIM reduces geometric conflicts.	Lean reduces failures processes.	Less rework = impact smaller environmental
EVE – Efficiency of Value Delivered	% of activities that add value	BIM identifies not productive activities	Lean eliminates value-added steps.	Reduces unnecessary resource consumption.
Waste Index (RCC/kg/m²)	Amount of waste generated	BIM quantifies materials	Lean minimizes excess.	Direct relationship with environmental sustainability.

Source: Prepared by the author, based on Sacks et al. (2010); Marzouk and Azab (2016); Akbari et al. (2024); Wong and Zhou (2015); Karanafti et al. (2024); McNeil-Ayuk and Jrade (2024); Mattana and Librelotto (2017); Daoud et al. (2025); Santos et al. (2021); Mellado and Lou (2020); Andújar-Montoya et al. (2019); Díaz, Sánchez and Guerra (2014).

The table presented organizes a set of essential indicators for evaluation. economic and financial aspects of projects that adopt the integration between BIM and Lean Construction. Such Metrics allow for the systematic monitoring of direct and indirect cost behavior. Budgetary predictability, efficiency of the production flow, and economic performance over time. of the business lifecycle. Indicators such as ROI, TCO, CPI, and SPI make it possible to measure returns, identify cost and schedule deviations, and estimate resulting financial impacts. rework, idle time, and production variability—factors widely discussed in the literature. as determinants for the project's profitability. By associating the informational accuracy made possible Through BIM and the productive rationality of Lean, these indicators become central instruments for Evidence-driven financial decisions, contributing to greater transparency in the allocation of resources, investment optimization, and financial sustainability of projects. Thus, the framework It synthesizes essential analytical tools for studies that prioritize cost control and... Economic competitiveness in the construction sector.

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In addition to economic and operational aspects, the literature shows that the integration between BIM and *Lean Construction* have a significant impact on various dimensions of sustainability. ranging from waste reduction to improvements in energy efficiency and governance of construction processes.

The systematization of these effects, presented in Table 3, demonstrates how each approach, In a complementary way, it contributes to environmentally responsible construction practices. economically viable and aligned with the circular economy. The framework organizes these interactions according to Sustainable dimensions, widely discussed in recent studies, allow us to visualize how the BIM offers analytical and informational support, while Lean operationalizes the elimination of... waste and production rationalization. The empirical and theoretical evidence listed reinforces that the The convergence between both methodologies strengthens the sector's ability to move towards similar models. More efficient, with a low environmental impact, and data-driven.

Table 3 – Convergences between BIM and Lean Construction in the Dimensions of Sustainability

Sustainable Dimension	BIM Contribution	Lean's Contribution	Evidence from the Literature
Waste Reduction	5D Models and Quantification you need materials	Elimination of waste	Karanafti et al. (2024); Schamne et al. (2022); Marzouk & Azab (2016)
Energy Efficiency	Thermoenergetic simulations and performance analysis	Stable flows reduce energy waste.	Akbari et al. (2024); Wong & Zhou (2015)
Circular Economy	Modeling for deconstruction and reuse	Lean processes reduce waste generation.	McNeil-Ayuk & Jrade (2024)
Sustainability Economic	Life cycle cost assessment	Reducing rework and deadlines.	Mattana & Librelotto (2017); Daoud et al. (2025)
Governance and Transparency	Shared collaborative models	Reliable planning and participation	Santos et al. (2021); Mellado & Lou (2020)
COÿ emissions	BIM calculates the impacts of materials.	Lean avoids unnecessary activities.	Akbari et al. (2024)
BIM Construction Quality	Reduces Compatibility errors of	Lean increases standardization and reliability	Andújar-Montoya et al. (2019); Díaz et al. (2014)

Source: Prepared by the authors, based on Karanafti et al. (2024); Schamne, Nagalli and Soeiro (2022); Marzouk and Azab (2016); Akbari et al. (2024); Wong and Zhou (2015); McNeil-Ayuk and Jrade (2024); Mattana and Librelotto (2017); Daoud et al. (2025); Santos et al. (2021); Mellado and Lou (2020); Andújar-Montoya et al. (2019); Díaz, Sánchez and Guerra (2014).

The chart systematizes the main dimensions of sustainability impacted by integration. between BIM and Lean Construction, highlighting how each approach contributes, in a way... complementary, for more efficient and environmentally responsible construction practices. It is observed that BIM plays a central role in the generation, analysis, and simulation of information, enabling to quantify materials, estimate emissions, assess energy performance, and model scenarios of deconstruction and reuse.

On the other hand, Lean philosophy provides the necessary operational principles for transforming such analyses into concrete actions, eliminating waste, stabilizing flows productive, reducing rework and encouraging processes that add value throughout the cycle of

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The life of the work. The literature analyzed reinforces that this methodological convergence enhances Results on multiple fronts: reduces solid construction and demolition waste, increases efficiency. Energy efficiency, promotes circular economy practices, improves sustainability indicators. It is economical and increases the transparency and governance of projects through collaborative models. Furthermore, empirical studies demonstrate that BIM-Lean integration directly contributes to... reducing the carbon footprint and improving construction quality by mitigating errors. compatibility and increased reliability of production stages. In this way, the framework summarizes... How the connection between digital technology and lean production constitutes a promising path for To advance the sustainability agenda in the construction sector.

Table 4 below summarizes the specific contributions of BIM and Lean philosophy. Construction in different analytical dimensions relevant to the construction sector. This Comparative organization allows one to clearly visualize how each approach works in a different way. complementary in improving production processes, information management and efficiency. operational, constituting a solid conceptual basis for understanding methodological integration between the two. By structuring the dimensions of analysis in parallel, the table facilitates the identification of individual potential and possible synergies between BIM and Lean, contributing to an evaluation a more comprehensive understanding of the economic, technical, and managerial implications of this convergence.

Table 4 – Contributions of BIM and Lean Construction to the Main Dimensions of Analysis of Construction

Dimension of Analysis	BIM – Building Information Modeling	Lean Construction
Official definition	Digital representation of the physical and functional characteristics of a facility, functioning as a shared information resource for decisions throughout the life cycle (NATIONAL INSTITUTE OF BUILDING SCIENCES, 2021).	A management philosophy focused on eliminating waste, maximizing value, and stabilizing the production flow, applied to construction (LEAN CONSTRUCTION process of INSTITUTE, 2024; LCI-BR, 2023).
Nature	Technology + information management processes.	Production philosophy + management system.
Conceptual origin	Evolution of CAD systems and the need for interoperability and integrated lifecycle management; consolidated by NBIMS-US and ISO 19650.	Based on lean production (Toyota Production System), adapted to the construction sector by Koskela (1992) and institutionalized by IGLC and LCI.
central objective	To integrate and structure reliable information for coordination, simulation, documentation, and decision-making.	Reduce waste, increase value, and improve the continuous flow of production.
Main focus:	Digital precision, interoperability, parametric modeling, multidimensional simulations (3D, 4D, 5D, 6D).	Process management, planning reliability, lean production, continuous improvement.
Tools typical	Modeling software (Revit, ArchiCAD, Navisworks, Tekla), CDE, IFC, energy simulations, 4D/5D.	Last Planner System®, Kaizen, Kanban, Value Stream Mapping (VSM), Takt Time, PPC (Percent Plan Complete).
Type of value generated	Conflict reduction, automatic matching, improved documentation, cost and time predictability, performance simulations.	Reduced variability, elimination of waste, increased productivity, stable flow.
Economic contribution	It improves estimates, reduces rework, increases budget accuracy, and enables cycle analysis.	It minimizes losses and waiting time, reduces unproductive time, and improves productivity.

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	of life. Reduces recurring costs.	
Environmental contribution	It enables LCA (Loadable Energy Acquisition), energy simulations, emissions analysis, and evaluation of sustainable alternatives.	It reduces waste generation, consumption, and excessive and unnecessary processes.
Implementation method	It requires technological training, standards, interoperability, and the adoption of collaborative digital operational and management environments.	It requires cultural change, discipline, and the adoption of collaborative management. and process stabilization.
Challenges	High initial cost, need for standardization, cultural resistance, low maturity of interoperability between software,	procedural resistance, sectoral fragmentation of the technique. construction.
Integration BIM-Lean	It provides data and models to optimize decisions.	It uses BIM information to improve Lean, simulate flow, and anticipate waste. planning, reducing variability, and optimizing production flow.
Synthesis	Information technology that structures and integrates data.	A management philosophy that organizes and disciplines processes.

Source: Prepared by the authors, based on Eastman et al. (2011); NBIMS-US (2015); Sacks et al. (2010); Koskela (1992); Womack and Jones (2003); Ballard and Howell (2003); Díaz, Sánchez and Guerra (2014); Andújar-Montoya et al. (2019); Oliveira, Silva and Amaral (2023); Santos et al. (2021).

The table demonstrates that BIM stands out as a modeling technology capable of... To generate accurate, multidimensional, and integrated information, supporting all phases of the lifecycle. of the project, from planning to operation. This informational capacity expands the Predictability reduces uncertainty and facilitates cost, schedule, energy performance and... compatibility of disciplines. On the other hand, the Lean Construction philosophy acts directly on managing processes, guiding the elimination of waste, the stability of the production flow, the Increased reliability and maximization of the value delivered to the customer.

When analyzed together, these dimensions show that BIM provides the foundation digital technology is necessary for rigorous analysis and informed decision-making, while Lean operationalizes this information through practices that rationalize the use of resources and avoid financial losses. Thus, the table not only organizes the roles played by each approach, but also highlights the complementarity that underlies the BIM-Lean integration. as an advanced management model, with a direct impact on economic efficiency and in sustainability in construction.

Table 5 – BIM–Lean–Sustainability Integration: Convergences, Benefits, and Results Expected

Dimension Integrated	**BIM Contributions**	**of Lean Construction**	**Results of Integration for Sustainability**	**Evidence from the Literature**
Reduction of Rework and Losses	Interference of detection; digital compatibility; simulations 3D/4D/5D	Elimination of non-value-adding activities; standardization and continuous flow.	Reduced use of materials and energy; lower costs and less waste.	Sacks et al. (2010); Marzouk & Azab (2016)
Efficiency in Use of Resources	Precise quantification of materials; performance analyses	Minimizing inventory; reducing idle time.	Optimization of inputs; smaller ecological footprint; reduction of indirect costs.	Akbari et al. (2024); Wong & Zhou (2015)
Life Cycle and Economics Circular	Modeling for maintenance, operation and deconstruction.	Reducing waste in the production cycle.	Increased durability; reuse of components; reduced C&D waste generation.	Karanafti et al. (2024); McNeil-Ayuk & Jrade (2024)

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Efficiency Economic and Predictability	Integrated cost estimates (TCO, 5D); real-time monitoring	Stable flow; reduced variability; production reliability.	Greater financial predictability; reduction of total project costs.	Mattana & Librelotto (2017); Daoud et al. (2025)
Governance, Transparency and Collaboration	Shared model; traceability	Collaborative planning; continuous improvement	Data-driven decision making; reducing asymmetries	Santos et al. (2021); Mellado & Lou (2020)
Performance Energetic and Emissions	Thermoenergetic simulations; materials analysis	Optimizing flows to reduce unproductive energy.	Lower CO_2 emissions and greater energy efficiency.	Akbari et al. (2024)
Quality and Performance Constructive	Information-rich models; reduction of design errors.	Standardization and stability of the flow	Buildings with higher quality, durability, and lower operating costs.	Andújar-Montoya et al. (2019); Díaz et al. (2014)

Source: Prepared by the authors based on Sacks et al. (2010); Marzouk and Azab (2016); Akbari et al. (2024); Wong and Zhou (2015); Karanafti et al. (2024); McNeil-Ayuk and Jrade (2024); Mattana and Librelotto (2017); Daoud et al. (2025); Santos et al. (2021); Mellado and Lou (2020); Andújar-Montoya et al. (2019); Díaz, Sánchez and Guerra (2014).

Table 5 presents a summary of the main interfaces between BIM, Lean Construction and sustainability, highlighting how integrating these approaches maximizes environmental gains, economic and operational. By combining the informational precision of BIM with rationality. Through Lean productivity, synergies emerge that can reduce waste and improve efficiency in the use of materials. of resources, increase financial predictability, and strengthen practices aligned with the circular economy.

These results are consistent with the author's own findings on social innovation and economics. Ecological and governance aspects of production systems, which highlight the importance of infrastructure. digital and collaborative approaches to promote socio-technical autonomy and territorial sustainability (Stroparo) et al., 2024; Stroparo; Floriani, 2024; 2025).

Final Considerations

The analysis performed through this *scoping review* made it possible to identify that the integration between BIM and Lean Construction constitute a promising strategy to address historical challenges of construction sector, especially those related to low productivity and high costs. operational issues and a lack of integration between design and execution. The literature shows that this Methodological convergence does not only represent the simultaneous adoption of digital technologies and managerial principles, but rather the construction of an integrated model of productive rationality. capable of optimizing flows, reducing waste, and increasing economic and financial predictability.

The studies evaluated suggest that BIM, by offering consistent informational bases, Intelligent three-dimensional models and performance simulations contribute decisively to Planning, monitoring, and controlling costs throughout the product lifecycle. undertaking. When linked to Lean principles — which emphasize continuous improvement, By eliminating losses and improving the reliability of planning, BIM enhances the efficiency of... processes, mitigating financial risks associated with rework, technical inconsistencies, and variations. unwanted changes in schedules (Sacks et al., 2010; Ballard; Howell, 2003). This synergy explains why

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numerous studies report significant cost reductions and superior productivity gains. to the observations when each approach is applied in isolation.

From an environmental perspective, the findings reinforce that BIM-Lean integration develops Lean plays a central role in promoting sustainable practices. The literature reviewed demonstrates that Lean It contributes to reducing waste of materials and energy, while BIM enables analysis. Predictive environmental performance and comparisons of more efficient construction alternatives. (Azhar et al., 2011; Wong; Zhou, 2015). Together, these approaches support decision-oriented to sustainability, reducing the environmental footprint of projects and promoting more efficient use. rational use of natural resources, consistent with contemporary principles of modernization ecological (Mol; Spaargaren, 2000).

The research also shows that performance indicators constitute elements Structuring elements in methodological integration. Metrics such as ROI, CPI, SPI, Takt Time, and indices of Variability allows for monitoring results, quantifying benefits, and supporting decision-making processes. based on data, increasing the transparency and governance of projects (Formoso et al., 2011; Frandson; Bergström; Tommelein, 2013). These indicators reinforce the role of BIM as digital management platform and Lean as a philosophy geared towards systemic efficiency.

Despite its potential, the literature points to significant challenges, particularly those related to organizational culture, sector fragmentation, and the initial investments required for The implementation of technologies and the lack of specialized training. Thus, the benefits of Integration depends not only on technological solutions, but also on structural changes that... They involve organizational processes, skills, and policies.

The findings of this study are consistent with the research agenda already developed by the author. especially those dealing with digital transformation, economic sustainability, and governance. Sociotechnics and innovation in production systems (Stroparo, 2024a; 2024b; Stroparo et al., 2025). Thus, the BIM-Lean integration resonates with previous work by demonstrating that Digital technologies and operational efficiency, when combined, strengthen management models. more efficient, sustainable and financially robust.

In summary, the conclusions of this study indicate that BIM-Lean integration represents a A consistent way to promote innovation, economic efficiency, and environmental sustainability in the sector. of construction. The convergence of these approaches provides a basis for productive modernization and for Strengthening the governance of projects, contributing to more constructive practices. Intelligent, transparent, and aligned with contemporary demands. New research may explore applied case studies, comparative analyses between sectors, or hybrid methodologies that broaden the understanding of the feasibility and impacts of the integrated adoption of these practices.

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